

REMARKS

Applicants submit that by the present Amendment and Remarks, this application is placed in clear condition for immediate allowance. At the least, the present Amendment clearly places the application in better condition for appeal. Moreover, the present Amendment does not generate any new matter issue in that the limitations of claim 4 have been incorporated into claim 1 and the limitations of claim 15 have been incorporated into claim 14. Ergo, no new issues are raised as claims 4 and 15 have always been before the Examiner. Accordingly, entry of the present Amendment and Remarks, and favorable consideration, are respectfully solicited pursuant to the provisions of 37 CFR § 1.116.

Claims 1 through 3, 5 through 14 and 16 through 20 are pending in this application. In response to the Office Action dated December 31, 2001, claims 1 and 14 have been amended. Care has been exercised to avoid the introduction of new matter. Specifically, the limitations of claim 4 have been incorporated into claim 1, and the limitations of claim 15 incorporated into claim 14. Consequently, claims 4 and 15 have been cancelled. Applicants submit that the present Amendment does not generate any new matter issue or any new issue for that matter.

A clean copy of amended claims 1 and 14 appears in the appendix hereto.

Claims 1 through 20 were rejected under 35 U.S.C. § 103 for obviousness predicated upon the acknowledged prior art in view of Solis.

In the statement of the rejection, the Examiner concluded that one having ordinary skill in the art would have been motivated to modify the acknowledged prior art methodology by employing a plasma containing CF₄ and H₂O, because it has a very aggressive ash rate of photoresist relying upon Solis. This rejection is traversed as legally erroneous.

Summary of the Invention

The present invention addresses the problem of fabricating high density semiconductor devices to achieve high circuit speed by employing low-k dielectric materials, such as HSQ. A recognized problem associated with HSQ is that it degrades when an oxygen containing plasma is employed to strip the photoresist. Degradation also occurs during solvent cleaning of a through hole. Such degradation takes the form of an increase in dielectric constant and moisture absorption, which moisture subsequently outgasses to generate voids (see page 5 of the written description of the specification, line 30 through page 7, line 16). Applicants have acknowledged prior attempts to employ HSQ without degradation (in the paragraph bridging pages 7 and 8 of the written description of the specification), which prior attempts include that selectively heating portions of the HSQ layer and stripping the photoresist mask in a hydrogen-containing stripping plasma. However, Applicants have found that such techniques undesirably reduced the stripping rate, thereby adversely impacting manufacturing throughput (page 11 of the written description of the specification, lines 28 through 33). Applicants address and solve that problem by employing a plasma containing CF_4 and H_2O to remove the photoresist mask and solvent cleaning and, unexpectedly, avoid degradation of the low-k (HSQ). That contribution is now embodied in independent claims 1 and 14, which specify that the dielectric constant of the gap fill layer and/or second dielectric layer does not increase more than about 15%. Among the separately argued dependent claims, claims 9 and 19 specify a removal rate of about 10 to about 20 $\text{K}\text{\AA}/\text{min}$.

Clear Legal Error

As will be developed infra, the Examiner in the Office Action dated December 31, 2001, committee **clear legal error** in concluding:

The plasma which is not disclosed by the primary reference is applied to a photoresist mask, and not a low-k material layer; therefore, the existence or absence of low-k material layers is not relevant to the issue at bar (ultimate sentence of page 3 of the December 31, 2001 Office Action).

As stressed in the Request for Reconsideration submitted October 16, 2001, it has been repeatedly held by the Court of Appeals for the Federal Circuit that in order to establish the requisite realistic motivation, the Examiner must make "clear and particular" factual findings as to a specific understanding or specific technological principle which would have realistically impelled one having ordinary skill in the art to modify a prior art reference (the acknowledged prior art method) to arrive at the claimed invention based upon facts--not generalizations. *Ruiz v. A.B. Chance Co.*, 234 F.3d 654, 57 USPQ2d 1161 (Fed. Cir. 2000); *Ecolochem Inc. v. Southern California Edison, Co.* 227 F.3d 1361, 56 USPQ2d 1065 (Fed. Cir. 2000); *In re Kotzab*, 217 F.3d 1365, 55 USPQ 1313 (Fed. Cir. 2000); *In re Dembiczak*, 175 F.3d 994, 50 USPQ2d 1614 (Fed. Cir. 1999). Moreover, and quite significantly, such motivation must be undertaken with a realistic expectation of success. *In re Vaeck*, 947 F.2d 488, 20 USPQ2d 1438 (Fed. Cir. 1991). As often stated by the Court of Appeals for the Federal Circuit, "obvious to try" is not the appropriate standard. *Ecolochem Inc. v. Southern California Edison, Co.*, *supra.*; *In re O'Farrell*, 853 F.2d 894, 7 USPQ2d 1673 (Fed. Cir. 1988); *In re Fine*, 837 F.2d 1071, 5 USPQ2d 1596 (Fed. Cir. 1988); *In re Dow Chemical Co.*, 837 F.2d 469, 5 USPQ2d 1529 (Fed. Cir. 1988).

Even more significantly, the Court of Appeals for the Federal Circuit has stressed that the requisite motivation must be undertaken from the viewpoint of one having ordinary skill in the art confronted with the same problem confronted by Applicants. *Ecolochem Inc. v. Southern California Edison, Co., supra*; and *In re Rouffet*, 149 F.3d 1350, 47 USPQ2d 1453 (Fed. Cir. 1998). This being the case, it is legally erroneous for the Examiner to ignore the use of a low-k dielectric material in the context of the claimed invention. The Examiner's disposition of the low-k material by saying "it is not relevant to the issue at bar" completely flies in the face of consistent judicial precedent which also requires that consideration be given to the problem addressed and solved by the claimed invention as an indicium of nonobviousness. *North American Vaccine, Inc. v. American Cyanamid Co.*, 7 F.3d 1571, 28 USPQ2d 1333 (Fed. Cir. 1993); *Northern Telecom, Inc. v. Datapoint Corp.*, 908 F.2d 931, 15 USPQ2d 1321 (Fed. Cir. 1990); *In re Newell*, 891 F.2d 899, 13 USPQ2d 1248 (Fed. Cir. 1989); and *In re Nomiya*, 509 F.2d 566, 184 USPQ 607 (CCPA 1975). Thus, the Examiner's assertion that the "low-k material layer is not relevant to the issue at bar" is legally erroneous, because the problem addressed and solved by the claimed invention must be given consideration not only in establishing the requisite motivational element but also as a potent indicium of nonobviousness. *Ecolochem Inc. v. Southern California Edison, Co., supra*; and *In re Rouffet, supra*.

There Is No Reasonable Expectation of Success

It is not disputed on this record that low-k dielectric materials suffer from degradation during photoresist stripping and solvent cleaning. *In re Clinton*, 527 F.2d 1226, 188 USPQ 365 (CCPA 1976). It is also not disputed that oxygen is employed during photoresist stripping after forming an opening in a low-k dielectric material. *In re Clinton, supra*. The Examiner says that

it would be obvious to modify such a conventional technique wherein oxygen is employed because one having ordinary skill in the art would have desired a "very aggressive ash rate of photoresist" disclosed by Solis. The Examiner's conclusion does withstand scrutiny for two reasons.

Firstly, as appreciated by the Examiner, Solis is not concerned with low-k dielectric material. In other words, the problem addressed and solved by the claimed invention does not exist in the context of Solis. Moreover, Solis is concerned with employing a plasma having a low etch rate or selectivity to titanium nitride, which is not the situation in the acknowledged methodology.

Secondly, the Examiner is hereby questioned: What is the **factual basis** to support the conclusion that one having skill in the art would have even desired or even contemplated as feasible the use of a plasma having a "very aggressive etch rate of photoresist" when removing a photoresist from a low-k dielectric material which is known to suffer from degradation upon photoresist removable? In this respect, the Examiner's attention is invited to the recent decision by the Court of Appeals for the Federal Circuit in *In re Lee*, ___ F.3d ___, 61 USPQ2.d 1430 (Fed. Cir. 2002), wherein the Court emphasized the need for a factual basis to support the motivational element. Indeed, *In re Lee, supra*, reinforced the requirement for "a convincing discussion of the specific sources of the motivation to combine the prior art references" enunciated by the Court in *Ecolchem Inc. v. Southern California Edison*, at 56 USPQ2.d 1065.

Secondly, Applicants would bring to the Examiner's attention U.S. Patent No. 6,433,143 issued on October 17, 2000 to Lin et al., a copy of which is appended hereto as Exhibit A. The reference to Lin et al. was cited during prosecution of the co-pending application mentioned in the first paragraph of page 1 of the written description of the specification. Applicants would

now rely upon Lin et al. as evidence of nonobviousness, because Lin et al. clearly teach away from what the Examiner suggests. Specifically, Lin et al. specifically disclose that the photoresist removal rate is to be conducted at a decreased rate in order to increase the duration of the photoresist removal rate in order to facilitate polymer removal. Applicants note that the plasma employed by Lin et al. contains oxygen which would degrade the low-k polymer. Such a problem does not even appear to be on the radar screen of Lin et al.

Where is the Reasonable Expectation of Success?

As previously pointed out, the requisite motivational element must be undertaken with a reasonable expectation of success. *In re Vaeck*, 20 USPQ2.d 1438. As also previously stressed "obvious to try" is not the appropriate legal standing. *Ecolochem Inc. v. Southern California Edison, supra*; *In re O'Farrell, supra*; *In re Dow Chemical, Co., supra*.

In applying such legal tenets to the exigencies of this case, Applicants submit that the Examiner did not establish the requisite realistic expectation of success. Again, the Examiner's refusal to consider the low-k material employed in the claimed method constitutes legal error, since it must be given consideration in establishing the requisite motivation element in the first place and as a potent indicium of nonobviousness. Furthermore, Solis, the alleged teaching reference, makes no mention of a low-k material. Ergo, Solis is not concerned with preventing the degradation of low-k dielectric material.

As previously pointed out, it is not disputed that low-k dielectric materials suffer from degradation during photoresist stripping. Under such circumstances, it is completely counterintuitive to arbitrarily say that one having ordinary skill in the art would have been realistically led to employ a "very aggressive" etch gas mixture in situations when a low-k

dielectric material is involved. The Examiner should realize that the photoresist material being removed and the polymer residues being removed are on the low-k material. It is not irrelevant.

Further, Applicants separately argue the patentability of claims 9 and 19, which specify a very high removal rate -- bearing in mind that the independent claims specify that the low-k material is not degraded more than 15%. On this record, the Examiner has not established any reasonable expectation of success. *In re Vaeck, supra*.

Obviousness is not Inherency

To whatever extent the imposed rejection is predicated upon the theory that **if** the technique of Solis is applied during processing of low-k material, **then** the claimed invention would result, such an approach is legally erroneous. The Court of Appeals for the Federal Circuit has frequently held that such a back door approach to obviousness improperly confuses obviousness with inherency. *In re Rijckaert*, 9 F.3d 1531, 28 USPQ2d 1955 (Fed. Cir. 1993); *In re Shetty*, 566 F.2d 81, 195 USPQ 753 (CCPA 1977); *In re Newell*, 891 F.2d 899, 13 USPQ2d 1248 (Fed. Cir. 1989). Indeed, as held by the Honorable Board of Patent Appeals and Interferences in *Ex parte Schricker*, 56 USPQ2d 1723, 1725 (Fed Cir. 2000):

Inherency and obviousness are somewhat like oil and water-
they do not mix well.

Indicia of Nonobviousness

As previously pointed out, the problem addressed and solved by a claimed invention must be given consideration in resolving the ultimate legal conclusion of obviousness under 35 U.S.C. § 103. *North American Vaccine, Inc. v. American Cyanamid Co., supra*; *Northern Telecom*,

Inc. v. Datapoint Corp., supra; In re Newell, supra; and In re Nomiya, supra. None of the applied references addresses or solves the problem of low-k dielectric material degradation, much less the ability to remove a photoresist mask at a high removal rate without degrading the underlying low-k dielectric material.

Further, as previously pointed out, Lin et al. expressly teach away from the claimed invention. Such a teaching away from the claimed invention constitutes another potent indicium of nonobviousness. *In re Zurko*, 111 F.3d 887, 42 USPQ2d 1476 (Fed. Cir. 1997); *In re Bell*, 991 F.2d 781, 26 USPQ2d 1529 (Fed. Cir. 1993); *Specialty Composites v. Cabot Corp.*, 845 F.2d 981, 6 USPQ2d 1601 (Fed. Cir. 1988); and *In re Hedges*, 783 F.2d 1038, 228 USPQ 685 (Fed. Cir. 1986).

The Evidence in the Specification

The Examiner committed further legal error in ignoring the evidence in the specification, which must be given consideration, as must all evidence relating to nonobviousness. *In re Soni*, 54 F.3d 746, 34 USPQ2d 1685 (Fed. Cir. 1995); and *In re Margolis*, 785 F.2d 1029, 228 USPQ 940 (Fed. Cir. 1986).

The evidence in the specification, notably the comparative data appearing at page 18 of the written description of the specification, demonstrate a dramatic preservation of SiH bonds attended upon the claimed invention vis-à-vis conventional solvent cleaning and oxygen plasma techniques. In the face of such evidence: **How** can the Examiner say that the low-k material employed in the claimed invention "is not relevant to the issue at bar"?

The Dependent Claims

Applicants separately argued patentability of each claim. As the Examiner has not separately addressed each dependent claim, Applicants submit that the Examiner has not established a *prima facie* basis to deny patentability to each dependent claim. Ergo, Applicants are not even under any burden to offer a rebuttal. *In re Deuel*, 51 F.3d 1552, 34 USPQ2d 1210 (Fed. Cir. 1995); *In re Rijckaert*, 9 F.3d 1531, 28 USPQ2d 1955 (Fed. Cir. 1993); *In re Bell*, 991 F.2d 781, 26 USPQ2d 1529 (Fed. Cir. 1993); *In re Fritch*, 972 F.2d 1260, 23 USPQ2d 1780 (Fed. Cir. 1992); and *In re Oetiker*, 977 F.2d 1443, 24 USPQ2d 1443 (Fed. Cir. 1992).

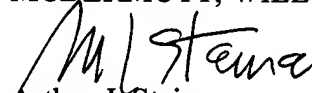
Conclusion

It should, be apparent, that a *prima facie* basis to deny patentability to the claimed invention has not been established has not been established for lack of the requisite realistic motivation. Moreover, the Examiner has committed legal error by ignoring the low-k dielectric material employed in the claimed invention. The Examiner has also committed legal error by ignoring the problem addressed and solved by the claimed invention, and by ignoring the evidence in the specification. Further, Lin et al. teach away from the claimed invention. Under such circumstances, the conclusion appears inescapable that one having ordinary skill in the art would **not** have found the claimed invention as a **whole** obvious within the meaning of 35 U.S.C. § 103. *In re Piasecki*, 745 F.2d 1468, 223 USPQ 785 (Fed. Cir. 1984). Applicants, therefore, submit the imposed rejection of claims 1 through 20 under 35 U.S.C. § 103 for obviousness predicated upon the acknowledged prior art in view of Solis is not legally viable and, hence, solicit withdrawal thereof.

To the extent necessary, a petition for an extension of time under 37 C.F.R. 1.136 is hereby made. Please charge any shortage in fees due in connection with the filing of this paper, including extension of time fees, to Deposit Account 500417 and please credit any excess fees to such deposit account.

Respectfully submitted,

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APPENDIX

Claims 1 and 14 now read as follows:

1. A method of manufacturing a semiconductor device, the method comprising:
forming a first dielectric layer on a substrate;
forming a first patterned conductive layer having gaps on the first dielectric layer, the first patterned conductive layer comprising a first conductive feature having an upper surface and side surfaces;
depositing a dielectric gap fill layer to fill the gaps;
depositing a second dielectric layer on the first patterned conductive layer and on the gap fill layer, wherein the as-deposited gap fill layer and/or second dielectric layer have a dielectric constant no greater than about 3;
forming a photoresist mask on the second dielectric layer;
forming a through-hole in the second dielectric layer exposing the upper surface of the first conductive feature; and
removing the photoresist mask and cleaning the through-hole with a plasma containing carbon tetrafluoride (CF₄) and water vapor (H₂O) such that the dielectric constant of the as deposited gap fill layer and/or the second dielectric layer does not increase more than about 15%.
14. A method of manufacturing a semiconductor device, the method comprising:
depositing a layer of dielectric material, having an as-deposited dielectric constant no greater than about 3, over a conductive region or conductive feature;
forming a through-hole in the dielectric layer exposing the upper surface of the conductive region or conductive feature; and

removing the photoresist mask and cleaning the through-hole with a plasma containing carbon tetrafluoride (CF_4) and water vapor (H_2O) such that the dielectric constant of the dielectric layer does not increase more than about 15%.